RF Exposure Policies
Updates on Draft KDB Publication 447498

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Note: The views expressed in this presentation are those of the authors and may not necessarily represent the views of the Federal Communications Commission.

Part II

Topics:

- KDB 447498 Revision and Transition
- Evaluation of Unintentional Radiation Sources for RF Exposure
- Far-Field Data for RF Exposure Power Estimates
- Addressing Comments on KDB 447498 Draft
- Equipment Authorization Policies and §1.1307
- Coming Soon: SPLSR Criterion Updates
- Modules: Simultaneous Transmissions in Hosts
- Conclusions

KDB 447498 Revision and Transition (I)

- Until further notice, either 447498 D04, or the previous KDB Pub. 447498 D01 v06 may continue to be used:
  - No mix of old and new procedures within application filings
  - A transition period date will be announced (with ample advance notice)
- For devices using 447498 v06 and not subject to PAG:
  - Form-731s and associated grants must be submitted to FCC by a TCB on or before the end of the transition period
- For devices using 447498 v06 and subject to PAG:
  - TCB must submit PAG KDB inquiry and fully-populated Form-731 application on or before the end of the transition period

KDB 447498 Revision and Transition (II)

- Comment period for draft publication ended on Oct 21

Expected Next-steps Timeline

- End of Nov 2022: review of all comments filed
- End of Dec 2022: publication updates
- End of Jan 2023: review and release of new version of 447498

Unintentional Radiators Sources (I)

- New guidance in KDB 447498 will discuss provisions for evaluation of RF exposure contribution from Unintentional Radiator Sources (URS)
- Simplifications being considered for URS power estimates based on:
  - Electric field strength measurements in the far-field (including data from URS already evaluated for Part 15 B compliance)
  - Radiated emissions from a small dipole
- The proposed approach leverages well-established exemption criteria for intentional radiators ("1-mW" exemption included)
- Examples for filing purposes to be added in the KDB 447498, including reference to use of EMC data

Unintentional Radiators Sources (II)

Power Estimates Based on Electric Field Strength Measurements

- Radiated power from an isotropic radiator

$$P_{rad} = \frac{2\,E^2\,\pi\,r^2}{\eta}$$

where P_{rad} is the power averaged over a wave period, E is the maximum amplitude of the sinusoidal wave, r is the distance of the measurement point in the far-field from to the center of symmetry of the URS radiating structure (all S.I. units), and $\eta=120\pi$

- P_{rad} may also be derived via approximate, albeit conservative estimates based on far-field data (*e.g.*, collected for Part 15B compliance)

Unintentional Radiators Sources (III)

Power Estimate Based on Equivalent Dipole Model

- URS emitted power approximated by considering an equivalent small dipole model

$$P_{rad} = \frac{\eta \pi}{3 c^2} (I_0 l f)^2$$

where I_0 is the URS RF current, l is the equivalent dipole length, and f is the frequency, $\eta=120\pi$, and c is the speed of the light (S.I. units)

Unintentional Radiators Sources (IV)

Example - 1 mW Exemption for Fast Microprocessor CPU

- Assuming that the estimated URS parameters for the small dipole formulas are $I_0 = 0.1$ A, $l = 0.01$ m, and frequency $f = 3.6 \cdot 10^9$ Hz, applying the small dipole formula in the previous section yields:

$$P_{rad} = \frac{\eta \pi}{3} \left(\frac{I_0 l f}{c} \right)^2 = 0.0568$$

- Thus, the radiated power is about 57 mW, and the URS does not qualify for the 1 mW exemption.

Far-Field Data for RFX Power Estimates (I)

- The electric field needs to be measured in the far-field without near-field absorption by dissipative materials that would otherwise affect the outgoing power flow at a larger distance
- The direction of the maximum electric field can be estimated based on the geometrical features of the radiating structure and corroborated by a few spot checks taken along the principal symmetry axes of the device.

Note: RFX = RF eXposure

Far-Field Data for RFX Power Estimates (II)

- In these conditions, the near-field is characterized by only reactive components not contributing to the average power flow,
- The total radiated power computed via integration of the Poynting vector is independent on the integration surface enclosing an antenna.
- Thus, the integration can be performed in the far field of the antenna, resulting in a simpler calculation.

Addressing Comments on KDB 447498 Draft (I)

- Unless otherwise stated, all formulas are in S.I. units. Over-extending the use of "dB" units complicates, not simplifies the calculations
- "Errata" annex document updates Table B.1 reproducing correctly the formula from the text and adds definitions for the smoothing functions
- TER for SPLSR calculation: work in progress, addressed later in this presentation
- Typically, RF transmitter conducted power is considered for assessing the applicability of equipment authorization test exemptions (§1.1307 exemptions are more general):
- Total radiated power estimates from far-field data may be also be considered (see previous slides) e.g., from standard-compliant measurements

Addressing Comments on KDB 447498 Draft (II)

- More extensive Unintentional Radiators test exemptions based on Part 15B EMC test data will be described in detailed
- Devices meeting 15B limits are typically characterized by very low or negligible emissions: thus, aggregate emissions meeting 15B limits may be sufficient, and not require identification of each separate URS
- Provisions are being worked out for capturing special cases (e.g., emissions up to the 15B limit and over a large bandwidth)

Addressing Comments on KDB 447498 Draft (III)

- Efforts in place reflect industry-friendly, yet conservative approach, with only approximate analyses required:
  - SAR evaluations may include URS transmitters at different frequencies, with some variations allowed for SAR system calibration vs. frequency
  - Equivalent dipole parameters for URS test exemptions may be based on a reasonable, approximate guess-estimates
  - Part 15B-based estimates may require additional frequency components in addition to the peak emission frequency

Equipment Authorization Policy and §1.1307 (I)

- KDB 447498-draft, Sec. 1.3, provides direct connection between RF Exposure policies for certified equipment and the §1.1307 rule
- Accordingly, an equipment certification is considered
  - valid as "evaluation of the human exposure to RF radiation", thus meeting the requirement of 47 CFR 1.1307(b)(1)(i)(B) for an evaluation
  - sufficient to state compliance with § 1.1310, thus meeting requirement of 47 CFR 1.1307(b)(1)(i)(B) for a statement of compliance.

Equipment Authorization Policy and §1.1307 (II)

Exemption vs. Exclusion: a terminology clarification

- Past guidance used, in part, the "*test exclusion*" terminology
- 47 CFR 1.1307(b)(2) discusses exemptions (from evaluation to demonstrate compliance)
- New KDB 447498-draft harmonized with rule and proper semantics:
  - Exclusion conveys the idea of prohibition, prevention, blocking
  - Exemption conveys the idea of "not required", "not necessary", albeit it may be allowed
- The exemptions in KDB 447498 refer to specific testing is not being required, thus provide more streamlined compliance demonstration
- However, if preferred, full testing is allowed and accepted (thus, there is no test exclusion)

Equipment Authorization Policy and §1.1307 (III)

Frequency range [a]	FCC Rules	OET Equipment Authorization Policies
$f \leq 100$ kHz	N/A (under consideration) [c]	All devices assessed case-by-case, with field strength limits of E = 83 V/m and H = 90 A/m, in all body exposure relevant positions
100 kHz < $f \leq$ 300 kHz [b]	SAR limits in § 1.1310 (b), (c)	MPE limits at 300 kHz in Table 1 to § 1.1310(e)(1): E = 614 V/m and H = 1.63 A/m
300 kHz < $f \leq$ 4 MHz [b]	§ 2.1091 Mobile Devices: MPE limits in Table 1 to § 1.1310(e)(1)	MPE limits in Table 1 to § 1.1310(e)(1)
	§ 2.1093 Portable Devices: SAR limits in § 1.1310 (b), (c)	
4 MHz < $f \leq$ 6 GHz	§ 2.1091 Mobile Devices: MPE limits in Table 1 to § 1.1310(e)(1)	
	§ 2.1093 Portable Devices: SAR limits in § 1.1310 (b), (c)	
6 GHz < $f \leq$ 100 GHz	MPE limits in Table 1 to § 1.1310(e)(1) [c]	
100 GHz < $f \leq$ 3000 GHz	N/A (under consideration) [c]	

[a] For all $f \leq 6$ GHz, SAR limits in §§ 1.1310 (b), (c) can always be applied where available, in place of MPE limits
[b] Policies for 100 kHz < f ≤ 4 MHz reflect capabilities of available SAR measurement equipment. Numerical simulations may be also acceptable, under PAG
[c] NPRM, ET Docket No. 19-226; FCC 19-126, 34 FCC Rcd 11743

Synopsis of RF Exposure Limits in FCC Rules and OET Equipment Authorization Policies

Coming Soon: SPLSR Criterion Updates (I)

- As a reminder, the total exposure ratio TER is defined as:

$$TER = \sum_{k=1}^{N_S} \left(\frac{SAR_k}{SAR_{\lim}} \right) + \sum_{k=1}^{N_f} \left(\frac{MPE_{field,\,k}}{MPE_{field,\,\lim}} \right)^2 + \sum_{k=1}^{N_{PD}} \left(\frac{MPE_{PD,\,k}}{MPE_{PD,\,\lim}} \right)$$

with N_S, N_f, and N_{PD} referring to sources requiring SAR, field-MPE, or PD-MPE, respectively, and "*lim*" to the corresponding applicable compliance limit

- When SAR is applicable for all the simultaneous RF sources, if each source is compliant (*e.g.*, SAR<1.6 W/kg), but the sum of all SAR values is greater than the applicable limit (equivalent to TER>1), the SPLSR criterion may provide test compliance reduction

Coming Soon: SPLSR Criterion Updates (II)

- Per KDB 447498, the SPLSR criterion allows to consider a device compliant if

$$SPLSR = (SAR_i + SAR_j)^{1.5}/R_{i,j} < 0.04$$

for every pair (i,j) of transmitter antennas separated by a distant $R_{i,j}$ expressed in *mm*, and with stand alone evaluated SAR_i and SAR_j .

- OET Lab working on an extension of guidance for evaluating simultaneous transmission when
  - SAR for all RF sources, i.e., f <4 MHz or f >6 GHz
  - Each source is compliant when transmitting by itself
  - TER > 1
  - Additional conditions related an approximately co-planar placement of antennas are verified

Coming Soon: SPLSR Criterion Updates (III)

- In general, different transmitters may need to be evaluated either through SAR or MPE (either field-MPE, or Power Density-MPE)
- The SPLSR criterion is being investigated to generalize its applications to a wider frequency range
- For simplicity, a normalized "exposure ratio" ER, in a similar way to contributions of the TER, is defined as:

$$ER = \begin{cases} \dfrac{SAR}{SAR_{lim}}, & if\ SAR\ applies \\ \left(\dfrac{MPE_f}{MPE_{field,lim}}\right)^2, & if\ Field-MPE\ applies \\ \dfrac{MPE_{PD}}{MPE_{PD,lim}}, & if\ PD-MPE\ applies \end{cases}$$

Coming Soon: SPLSR Criterion Updates (IV)

- With the "exposure ratio" ER definition, one may easily write an equivalent expression to the present SPLSR formula for the cases where ER=SAR
- When considering ER based on MPE terms above 6 GHz, the simple extension of the current SPLSR criterion may lead to conservative estimates, due to the smaller extension of the near field for increasing frequencies
- The proper extension to MPE for less than 4 MHz is being investigated
- A comprehensive formulation is in progress and planned for the final edition of KDB 447498

Modules: Simultaneous Transmissions in Hosts (I)

Present, Well-Established Policy (KDB 447498 v06)

- The host integrator needs to establish whether a *Module*, while inserted in the host, will be operating in *integrated stand-alone* or simultaneous transmission conditions
- *Integrated stand-alone* operation refers to the *Module* transmitting while integrated in the host, but without any other transmitter operating in the host
- If the *Module* is transmitting while any other transmitter in the host is allowed to operate, then the simultaneous transmission operation shall be evaluated

Modules: Simultaneous Transmissions in Hosts (II)

RF Exposure Requirements for Stand-alone Operating *Modules*

- New guidance for *Modules* integration is being considered for forthcoming KDB 447498 v07
- Goal: to allow the host integrator to assess the applicability of the *Module* for integrated stand-alone operations in a particular host with minimal RF exposure evaluations.
- This guidance, for cases corresponding to the large values of *integrated stand-alone* RF exposure evaluation indicators (SAR or MPE), includes some restrictions on the hosts in which the *Module* can be integrated.

Modules: Simultaneous Transmissions in Hosts (III)

RF Exposure Requirements for *Modules* operating in Simultaneous Transmission Conditions

- The host integrator is solely responsible for ensuring that compliance is met for the Module integrated in the host according to the grant conditions and instructions
- Proposed guidance in Draft KDB 447498-DR05 Sec. 4.3 includes provision based on SPLSR criterion for evaluation of *Module* integration for simultaneous operations in the host
- This provision may significantly streamline the host integration options, also in consideration of the SPLSR extension (in progress) to TER evaluations

Conclusions

- Work in progress on several front to simplify guidance for compliance RF exposure
- Efforts with no compromises on safety, but accounting for consumer and industry and needs
- R&D at FCC Office of Engineering and Technology to ensure impartial validation of data and estimates